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METHOD OF PRODUCING INK JET CHAMBERS USING PHOTO-IMAGEABLE MATERIALS

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METHOD OF PRODUCING INK JET CHAMBERS USING PHOTO-IMAGEABLE MATERIALS

FIELD OF THE INVENTION

The invention relates generally to the field of ink jet recording heads, and in particular to a method of manufacturing an ink jet chamber. More specifically, the invention relates to the manufacture of specific ink jet chambers that enhance the performance of the ink jet recording process.

BACKGROUND OF THE INVENTION

An ink jet recording head typically includes outlets or nozzles that serve to eject tiny droplets of liquids used in a recording process onto a media, such as any suitable paper. Situated behind those nozzles is a chamber that contains either ink or fluid and a mechanism of either electrically or mechanically ejecting the ink or fluid onto a suitable receiver.

A more conventional method of manufacturing an ink jet recording head is represented in U.S. 5,478,606 by Ohkuma et. al., wherein a method of manufacturing an ink jet recording head has the steps of (1) forming an ink flow path pattern on a substrate with the use of a dissoluble resin, the substrate having ink ejection pressure generating elements thereon; (2) forming on the ink flow path pattern a coating resin layer, which will serve as ink flow path walls, by dissolving in a solvent a coating resin containing an epoxy resin which is solid at ordinary temperatures, and then solvent-coating the solution on the ink flow path pattern; (3) forming ink ejection outlets in the coating resin layer above the ink ejection pressure generating elements; and (4) dissolving the ink flow path pattern.

Consequently, a need exists for forming a ink jet chamber which reduces complexity, reduces manufacturing steps and lowers costs.

SUMMARY OF THE INVENTION

The present invention is directed to overcoming one or more of the problems set forth above. Briefly summarized, according to one aspect of the present invention, a method is detailed for the creation of one or more ink jet

chambers, the method comprising the steps of providing a substrate having a thermal element covered with substantially one type of uncured photo-imageable material; providing a first mask spanning the thermal element which creates both masked and unmasked uncured photo-imageable regions; exposing the unmasked photo-imageable region; providing a second mask covering at least a portion of the thermal element; exposing a portion of the remaining unexposed photo-imageable region for forming an output nozzle; curing the exposed portions of the photo-imageable material; and removing all the remaining uncured photo-imageable material for creating the ink jet chamber.

The above and other objects of the present invention will become more apparent when taken in conjunction with the following description and drawings wherein identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

Advantageous Effect Of The Invention

The present invention has the following advantages in that a thermal element covered with substantially one type of uncured photo-imageable material is used in the creation of an ink jet chamber. This method when considered over the prior art provides significant advantage in reduced complexity, reduced manufacturing steps and lower costs.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view of an ink jet chamber of the present invention positioned upon a substrate, showing the creation of features by exposing a photo-imageable material through a first mask;

Fig. 1a is a side view of an ink jet chamber of the present invention situated upon a substrate, showing the creation of features by exposing a photo-imageable material through a second mask;

Fig. 1b is a side view of an ink jet chamber of the present invention situated upon a substrate, showing finished features after curing and removal of uncured and unexposed photo-imageable material;

Fig. 2 is a side view of an ink jet chamber of the present invention, situated upon a substrate, showing multiple ink jet chambers with substantially similar chamber volumes and output nozzles;

Fig. 2a is a side view of an ink jet chamber of the present invention, situated upon a substrate, showing multiple ink jet chambers with substantially different chamber volumes and output nozzles;

Fig. 3 is a side view of an ink jet chamber of the present invention where an internal member provides a plurality of functions;

Fig. 3a is an end view of the ink jet chamber of the present invention taken along line 3a-3a of Fig. 3;

Fig. 4 is a side view of an ink jet chamber of the present invention in which a gradient mask creates plurality of geometrically shaped structures;

Fig. 5 is a side view of an ink jet chamber of the present invention in which a collimated light source creates plurality of geometrically shaped structures; and

Fig. 5a is a side view of an ink jet chamber of the present invention in which an uncollimated light source creates plurality of geometrically shaped structures by exposing through a mask.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig.1, there is shown a side view of an ink jet chamber assembly **10** situated upon a substrate **20**, which illustrates the creation of vertical structures (hereafter called a chamber wall) **30** by exposing a photo-imageable material **40** through a first mask **50**. First mask **50** is designed to both block and pass the exposing light **60.** The exposing light **60** that is passed by first mask **50** prepares the exposed portion of the photo-imageable material **40** through its entire thickness down to the substrate **20**. This produces an exposed photo-imageable material that becomes the chamber walls **30** horizontally adjacent to the thermal element **70**. The exposing light **60** used for exposing the photo-imageable material **40** through the first mask **50** can be variably adjustable in intensity, dose, and wavelength for the purpose of modifying the resultant structures produced in the photo-imageable material **40**. In regards to wavelengths of the exposing light

60, those wavelengths can consist of a plurality of conditions including fixed, variable, single, dual, multiple or mixed.

In the preferred embodiment, for example, the wavelength of the exposing light **60** is at 365nm corresponding to the I-line of a mercury light source. The exposure is performed with a contact or proximity aligner. Alternatively an I-line stepper can be used.

A typical photo-imageable material used in this invention is SU-8 2000 Photoresist available from MicroChem Corporation of Newton Massachusetts. SU-8 2000 (formulated in cyclopentanone) is a chemically-amplified, epoxy-based negative resist. Standard formulations are offered to cover a wide range of film thicknesses from <1μm to >200μms. The SU-8 2000 resist has a high functionality, high optical transparency and is sensitive to near UV radiation. Images having exceptionally high aspect ratios and straight sidewalls are readily formed in thick films by contact-proximity or projection printing. Cured SU-8 2000 is highly resistant to solvents, acids and bases and has excellent thermal stability, making it well suited for applications in which cured structures are a permanent part of the device.

Referring now to Fig. 1a, there is illustrated a side view of an ink jet chamber assembly **10**, of the present invention. It is positioned upon a substrate **20**, showing the creation of a horizontal structure (hereafter called a chamber roof) **80** by exposing the photo-imageable material **40** (from Fig.1) through a second mask **90**. It is apparent to those skilled in the art that the first mask **50** has been discarded and replaced by second mask **90**. Second mask **90** is designed to both block and pass the exposing light **60**. The light that is passed by second mask **90** prepares the photo-imageable material **40** for producing an exposed photo-imageable material **40**, which becomes the chamber roof **80** positioned vertically above and adjacent the thermal element **70**. This second exposure is preferably performed immediately following the first exposure described in Fig. 1a. Alternatively, for robustness, a short baking under heat is performed prior to second exposure. The exposing light **60** used for exposing the photo-imageable material **40** through the second mask **90** can be variably adjustable in intensity, dose, and wavelength for the purpose of modifying the

resultant structures produced in the photo-imageable material **40** (from Fig. 1). In regards to wavelengths of the exposing light **60**, those wavelengths can consist of a plurality of conditions including fixed, variable, single, dual, multiple or mixed.

In a preferred embodiment, the wavelength of the second exposing light **60** is at 365nm and the process described after the first mask **50** is repeated. In an alternative embodiment, the wavelength of the second exposure light is selected from lower wavelength lines of a mercury light source. For example, lines in the 320nm wavelength region can be used. The reduced transparency of the photo-imageable material **40** at this lower wavelength allows finer tuning of the chamber roof thickness **80** and also provides less dependence on substrate reflectivity.

Still referring to Fig. 1a, a shaded area that represents unexposed photo-imageable material **100** remains (formerly **40** at Fig 1). It will be instructive to note that a semi-finished ink jet chamber exists with both exposed chamber walls **30** and an exposed chamber roof **80**, and that the aforementioned controlled variability of the exposing light **60** is used to control both the height of the chamber walls **30** and the thickness of the chamber roof **80**, as described hereinabove. The lack of any exposure over the thermal element **70** creates by default an ink jet nozzle **110**. At this point, the chamber walls **30** and chamber roof **80** are baked to complete the hardening process for the exposed photo-imageable material **40**, but leaves any unexposed photo-imageable material **100** unaffected and removable. The removal of the unexposed photo-imageable material is accomplished by flushing with a solvent such as cyclopentanone. After flushing is complete, a final cure at a temperature of at most 200 degrees Centigrade finalizes the ink jet chamber assembly **10** drawn in Fig. 1b.

Referring to Fig. 1b, there is illustrated a side view of the completed and processed ink jet chamber assembly **10** of the present invention. It is positioned upon a substrate **20**, and shows chamber walls **30** upon which is situated a chamber roof **80** and an ink jet nozzle **110** created by washing out the unexposed photo-imageable material **100** (the process described in the previous paragraph). The ink jet nozzle **110** is shown disposed substantially directly above and adjacent the thermal element **70**, and adjacent to a vertical support member

120. It is instructive to note that a supply port **160** is subsequently put into the substrate **20** for permitting inks or fluids to pass into the ink jet chamber assembly **10**.

Referring now to Fig. 2, there is shown a side view of a plurality of ink jet chambers **10**. The process as described previously was, for descriptive clarity, described for creating a single ink jet chamber **10**. However, the present invention also provides the ability to produce a plurality of ink jet chamber assemblies **10** upon the same substrate **20**, which greatly enhances the reduced complexity, reduced manufacturing steps and lower costs achieved by the methods described in this invention. Those skilled in the art will readily be able to apply the above teachings to the plurality of ink jet chambers **10**. Additionally, it is instructive to note that Fig. 2 details a plurality of ink jet chamber assemblies **10** with essentially the same internal structure and volumes with regards to one another.

Referring next to Fig. 2a, there is shown the ink jet chamber assemblies **10** situated on the substrate **20**, and having different internal structure and volumes with respect to one another, such as nozzle dimensions and chamber volumes. This illustrates how the present invention can be modified by using different masks along with different exposures to control the formation of different features in a plurality of ink jet chamber assemblies **10**.

Referring next to Figs. 3 and 3a, there is illustrated a finished and cured ink jet chamber assembly **10** situated on substrate **20**. A vertical support member **120** is a support for the chamber roof **80**, but it can also be manufactured with an additional function in mind such as filtering an impurity such as dust that may be suspended within a supplied ink or fluid (not shown). This filtering function would be engineered in a manner that integrates the filter as a plurality of posts **135** across the ink jet chamber with predetermined spacing between the posts **135** for the blocking of impurities and drawn in Fig. 3a. Supplied inks or fluids (not shown) would be sourced from a reservoir (not shown) through the supply port **160**. Alternatively, posts **135** may be a single integrated wall composed of a porous material for permitting the filtering. Additionally, post **135** may serve as baffles.

In operate the ink jet chamber, electrical energies applied to the thermal element **70** ejects inks or fluids (not shown) from an ink jet chamber assembly **10** through an ink jet nozzle **110**. The process of ejecting ink creates shock waves within the ink jet chamber assembly **10** that are severe enough to limit the lifetime of the ink jet chamber assembly **10**. Baffles serve the function of dampening the shock waves thus increasing the lifetime of the ink jet chamber assembly **10**.

Referring now to Fig. 4, there is shown an alternative method for producing chamber walls **30** that have a slanted chamber wall **180**. In this case, exposing light **60** passes through a gradient mask **170** for producing the slanted chamber walls.

Referring next to Fig. 5, the same effect can be achieved by using a collimated light source **200** to directly expose the photo-imageable material **40** (referring back to Fig. 1) or using an un-collimated light source **210** through a third mask **190** detailed in Fig. 5a.

The invention has been described with reference to a preferred embodiment. However, it will be appreciated that variations and modifications can be effected by a person of ordinary skill in the art without departing from the scope of the invention.

PARTS LIST

10	ink jet chamber assembly/assemblies
20	substrate
30	vertical structures (chamber wall)
40	photo-imageable material
50	first mask
60	exposing light
70	thermal element
80	horizontal Structure (chamber roof)
90	second mask
100	unexposed and uncured epoxy photo-imageable material
110	ink jet nozzle
120	vertical support member
135	posts
160	supply port
170	gradient mask
180	slanted chamber wall
190	third mask
200	collimated light source
210	un-collimated light source